HOW CAN WE MOVE COMMUTERS FROM PRIVATE TO PUBLIC TRANSPORT? A CASE STUDY OF CAR AND BUS MODAL CHOICES IN JOHANNESBURG

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ABSTRACT

One of the main transport policy strategies that government can address to make transport sustainable is to influence private transport users to move from private to public transport. With the high increase in fuel prices over the past year and global warming, sustainable transport, and specifically fuel saving measures, were given new priority by international and local governments.

In view of the increased priority locally on sustainable transport, a case study in Johannesburg undertaken to estimate mode choice factors of bus and private transport users in the inner-city areas, is reviewed to assist government on the most significant policy measures they can take to move private transport users to public transport. The study took the form of a stated preference discrete choice study conducted as part of the development of the GTS2000 transport model for Gauteng by the Gauteng Department of Transport, Roads and Public Works.

The paper covers the design of the survey and the SP experiments, the main survey results, the calibration results of discrete mode choice models, and sensitivity analysis of the impact of the choice factors on modal split. Finally conclusions are drawn on the most effective and efficient policy measures to achieve a shift in mode choice in favour of public transport.

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INTRODUCTION

One of the main transport policy strategies that government can address to make transport sustainable is to influence private transport users to move from private to public transport. With the high increase in fuel prices over the past few years, sustainable transport, and specifically fuel saving measures, was given new priority by international and local governments. This coincides with the increasing concern internationally on the negative impacts of global warming, which is another motivation to promote public transport over private transport. A major international research study had been undertaken to "*develop a more rigorous understanding of the conditions under which the process of growing unsustainable transport demand could be reversed, by changing travelers', shippers' and carriers' behaviour (Rizet, 2008).*"

In South Africa the main debate and focus of planners was on improving public transport mainly to retain public transport captive users. With the increases in incomes of the poor communities over the last decade, coupled with poor public transport, the main trend in travel behaviour was for public transport users to buy cars as soon as they can afford it. Little attention was given to influencing higher income private transport users to make use of public transport. Fortunately, two factors in SA are working together to make significant progress in this regard. These are the priority and funding given by government to invest in modern public transport systems for the 2010 Soccer World Cup and leaving a legacy afterwards, as well as the international sharp increase in fuel prices. Good examples of the modern public transport systems are the Gautrain high-speed train services in Gauteng, and the planned Bus Rapid Transit (BRT) systems in many cities in South Africa.

The Gauteng Department of Public Transport, Roads and Works completed the comprehensive re-calibration of its strategic transport model (GTS 2000 Model) in 2006 from first principles (Gauteng Department of Roads and Public Works, 2006). One of the main purposes of the re-calibration of the GTS 2000 Model was to give the model a strong public transport capability. The model needs to support the government's policy to promote and restructure public transport and to serve user needs. The emphasis of current transport legislation, policies and planning, such as the National Land Transport Transitional Act (2000) and Integrated Transport Plans, is on user preferences and meeting user needs. The model therefore needed to have a strong behavioural basis based on user preferences. Discrete choice stated preference (SP) models provided the ideal technique to achieve these objectives.

A review of SP mode choice models developed in Gauteng province indicated that a large number of studies have been conducted amongst low-income public transport captive communities(Gauteng Department of Roads and Public Works, 2006, Del Mistro and Arentze, 2002, Van Zyl, Lombard, and Lamprecht, 2001). These model parameters could therefore be transferred to the Gauteng modal split model, which would save time and cost. However, it was realised that there is a gap in the market segments that would be important to address. This was the middle-income market of car users, who have a choice between car and bus. Appropriate strategies of improving bus services to attract users from private transport are regarded as one of the important strategies to test, and which have the best potential to attract car users to public transport.

It was therefore decided to conduct a small SP survey amongst car and bus users in order to calibrate a binary modal split model of car and bus mode choice. This paper summarises the SP study that was conducted, with a view to assisting government on the most significant policy measures they can take to move private transport users to public transport (Gauteng Department of Roads and Public Works, 2006)

A professional market research company was appointed to conduct SP surveys to obtain information from short-distance car and bus commuters in Johannesburg regarding their choices between car and bus transport.

The paper covers the following:

- design of the survey and the SP experiments;
- the main survey results;
- the calibration results of discrete mode choice models;
- sensitivity analysis of the impact of the choice factors on modal split; and
- finally conclusions are drawn on the most effective and efficient policy measures to achieve a shift in mode choice in favour of public transport;

SURVEY DESIGN AND FIELDWORK

The objective of the survey was to obtain information from short-distance car and bus commuters in Johannesburg regarding their choices between car and bus transport. The survey was designed to estimate RP and SP mode choice models for the GTS 2000 Model.

The sample of the respondents consisted of 200 car and 100 bus users. Table 1 gives the distribution of the sample among different areas, while Table 2 gives the distribution among population groups and genders.

Table 1: Distribution of sample among areas

AREAS SAMPLED	BUS USERS	CAR USERS	TOTAL
Malvern	20	40	60
Kensington	20	40	60
Newlands	19	41	60
Paarlshoop, Homestead Park, Mayfair West, Mayfair	21	39	60
Westbury, Brixton	20	40	60
Total	**100**	**200**	**300**

Table 2: Gender, population group and modal distribution

USERS		BUS		CAR	
Total		**100**		**200**	
Population group	Black	36	36%	76	38%
	Coloured	18	18%	66	33%
	Indian	19	19%	26	13%
	White	27	27%	32	16%
	Total	**100**	**100%**	**200**	**100%**
Gender	Male	50	50%	107	54%
	Female	50	50%	93	46%
	Total	**100**	**100%**	**200**	**100%**

Only those commuters who had a choice of mode and who had recently used car and bus for their trip to work had been included in the survey. Car users were targeted who were in close proximity to the main bus routes to the CBD.

All of the respondents were adults, average age of 35 years, who lived in neighbourhoods relatively close to the Central Area of Johannesburg, where they also worked (less than 20 km).

The questionnaire elicited socio-economic information from the respondents and their households, and trip information relating to the respondent's usual mode of travel (either bus or car) as well as alternative mode. The questions on the alternative mode allowed RP models to be calibrated. Attitudinal questions were also included on why the respondent preferred his usual mode of transport, and why he/she did not use the alternative mode more often.

Separate questionnaires were designed for bus and car users, although obtaining the same information, but distinguishing between the different contexts of the bus and car users. Up-front screening questions established whether the respondent was employed and whether he was a car or bus user. Only employed bus or car users were interviewed.

A pilot survey was first conducted to test the questionnaire and the SP design. Some changes were made to the questionnaire, including adjustment of some SP levels, based on the pilot survey.

The survey methodology involved face-to-face interviews of respondents at home in their preferred language. Computer Aided Personal Interviews (CAPI) was used with dynamic data validation.

Bus users were recruited at bus stops, while car users were recruited at their homes within walking distance from bus stops. The survey was conducted from 1 to 24 November 2003.

SP DESIGN

The SP design focussed on testing mainly time and cost variables for the purposes of developing a strategic transport model. In addition, the number of SP choices had to be limited in order to prevent respondent burden. The main objective was to test the preferences of middle-income car commuters when considering the choice between car and bus. The best market for bus among car users was considered to be middle-income suburbs located relatively close to the CBD. The survey therefore targeted this market.

The following five variables were selected for testing:

- Walk time from home to bus (min.)
- Wait time for bus (min.)
- In-vehicle travel time (min.)
- Travel cost (Rand) – difference between bus fare and car fuel cost
- Parking cost per day for car (Rand)

Three levels of each variable were tested, yielding a full factorial design of 243 choices. A 16-choice fraction was selected, allowing main effects to be tested independently.

Variables were described, relative to each respondent's actual travel times and cost, except for walk and wait time by bus, which were fixed levels. The Computer Aided Personal Interviews (CAPI) allowed the generation of the SP levels based on each respondent's own travel context. Previous experience indicated that this improved the goodness of fit of the SP models as a result of the higher data variation (Van Zyl, Lombard, and Lamprecht, 2001)

The design was pilot-tested and minor modifications were made. A concern was respondents choosing only car. This was addressed by screening respondents to those who are willing to consider bus as a viable alternative, even though they might not have bus available to them. Parking costs were also increased in the SP experiment to entice car users to choose bus for some scenarios.

SURVEY RESULTS

This section provides a selection of the most interesting survey results comparing factors impacting on users' mode choices.

Income

Figure 1 shows the personal income distribution of bus and car users. The average personal monthly income of bus users was R 4 686 and of car users was R 6 045. The average monthly household income of bus users was R 9 244 and of car users was R10 282. Interestingly the incomes of car users were not much higher than that of bus users.

Travel distances and speeds

The average distance for bus trips from home to work was 10.1 km. The average duration of the trip was 22 minutes, which implies an average speed of 27.7 km/h. The average distance for car trips from home to work was 9.9 km. The average duration of the trip was 18 minutes, which implies an average speed of 33.1 km/h.

In congested conditions the average speed of cars is therefore not much higher than that of bus.

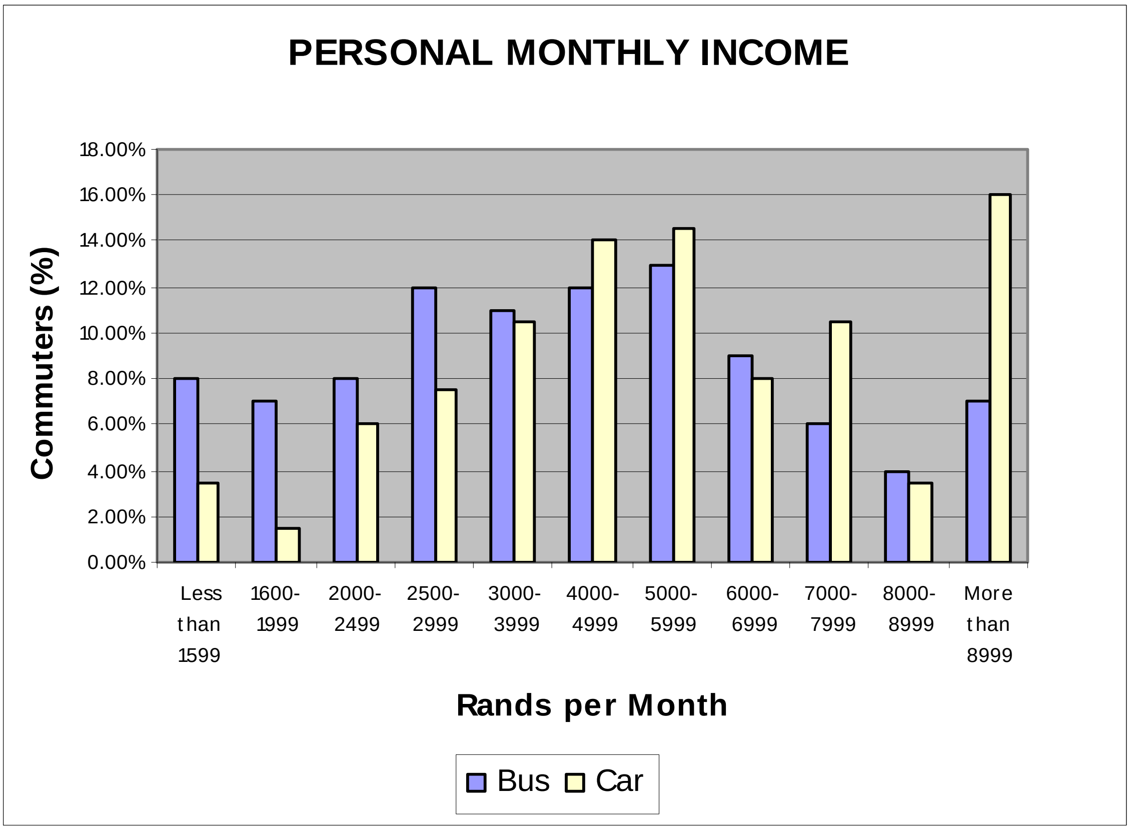

Figure 1: Personal monthly income of bus and car users

Travel Time

Table 3 shows the average walking, waiting and in-vehicle travel times reported by bus and car users for their current mode and alternative mode. Bus users perceive their alternative car mode to provide shorter in-vehicle and total travel time to that of bus. Car users perceive their alternative bus mode to provide longer in-vehicle travel time and total travel time to that of car.

The average perceived walk time to the bus stop from home by car users was approximately 10 minutes, double the average walk time reported by bus users. Car users would therefore be more likely to use bus if they were closer to the bus stop. This was confirmed in the SP analysis discussed in the next section.

Table 3: Average walking, waiting and travel times reported by bus and car users for their current and alternative modes

AVERAGE TRAVEL TIMES REPORTED BY BUS USERS (min)						
Mode		**Walk Home**	**Wait Home**	**In-veh Travel**	**Walk Work/ Park**	**Total**
Bus (Current mode)		5.3	9.0	22.0	6.0	**42.3**
Car (Alt mode)	**Driver**	-	-	15.8	9.2	**25.0**
	Passenger	-	2.2	16.3	3.6	**22.0**
	Lift Club	-	3.6	16.4	3.6	**23.6**
AVERAGE TRAVEL TIMES REPORTED BY CAR USERS (min)						
Mode		**Walk Home**	**Wait Home**	**In-veh Travel**	**Walk Work/ Park**	**Total**
Bus (Alt mode)		9.6	7.16	26.1	6.9	**42.6**
Car (Current mode)	Driver	-	-	18.2	3.1	**21.3**
	Passenger	-	4.1	17.6	3.9	**25.5**
	Lift Club	-	4.6	20.5	4.3	**29.4**

Availability of Alternative Modes

All of the bus users had the opportunity of travelling by car. Some 51% had used it at least once in the last month, 22% in the last 3 months and 27% in the last 6 months.

Table 4 shows the ways in which bus users can travel by car. Most can use car as a passenger.

Table 4: Ways in which bus users can travel by car

	COMMUTERS	**%**
Driver	14	14%
Passenger	75	75%
Lift Club	11	11%
TOTAL	**100**	**100%**

Tables 5 and 6 show the ways in which car users' travel by car and bus availability.

Most car users drive a car, but a significant number travel as a passenger. Some 60 % of car users said that they had bus available to them.

Table 5: Regular ways in which car users travel by car

CONDITION	**COMMUTERS**	**%**
Driver	124	62%
Passenger	65	33%
Lift Club	11	6%

Table 6: Availability of bus to car users

AVAILABLE	**COMMUTERS**	**%**
Yes	120	60%
No	80	40%

Attitudes towards bus and car travel

The main reasons mentioned by bus users for choosing bus as their preferred mode are:

- Cost effective/cheaper/affordable (48%)
- Safe from accidents (13%)
- Safe (unspecified reason) (9%)

The main reasons for not travelling by car more often are:

- The car is expensive (38%)
- Not having a car (23%)
- Bus is more convenient, because the passengers with whom they can share car travel, work at different hours (7%)

Reasons mentioned by car users for choosing car as their preferred travel mode are:

- The car is faster (25%)
- The car is more convenient (unspecified reason) (16%)
- Not having to wait for a long time (10%)

Main reasons that car users do not travel by bus more often are:

- Have to wait too long at the bus stop (14%)
- The bus is too slow and time consuming (14%)
- Bus time schedule is not suitable for their needs (10%)

A large percentage of bus and car users therefore indicated time, cost and mode availability factors influencing their mode choice, which can be influenced by transport authorities. These factors are typical of those that can be included in travel demand models for policy testing purposes.

MODEL CALIBRATION

Table 7 gives the best model estimated on the sample of car users from the SP survey. Due to missing values in the RP variables included in the SP model, only 155 of the 200 car users were in the SP sample. The RP variables were personal income and experience of bus usage.

The sample included car users who reported that they did not have bus available to them. The purpose of the SP model was to test latent demand as well from car users who have little experience of using bus, or no experience of using bus.

Various RP models were tested using the car and bus sample, but these gave very poor results.

The SP models gave a very good fit, and the best one gave a Rho-square value of 0.27. See Ortuzar and Willumsen (2006) for an explanation of discrete choice and stated preference models and how to test their goodness of fit. All the coefficients of the model in Table 7 are significant at a 95 % level (t-value > 2) and have intuitively the correct signs.

Table 7: Coefficients and significance of best sp model

MODES	VARIABLES	UNITS	VOT	COEFF	t-VALUES
Car	In-veh time (SP)	Mins per trip	R 24.9	-0.069	-7.0
Car	Park cost (SP)	R per day		-0.075	-5.7
Car	Fuel cost (SP)	R per trip		-0.166	-3.9
Car	Personal income (RP)	R per month		3.450E-05	3.1
Bus	Wait time home end (SP)	Mins	R 6.1	-0.035	-4.0
Bus	Walk time home end (SP)	Mins	R 8.3	-0.047	-3.2
Bus	In-veh time (SP)	Mins per trip	R 11.6	-0.066	-8.9
Bus	Fare (SP)	R per trip		-0.343	-5.8
Bus	Experience (RP)	Dummy		-0.261	-2.9
Generic	Inertia to change	Dummy		4.252	15.1
Asc	Car			-0.991	-5.0
Number of records = 2480; Rho-Square = 0.27					

Personal income is significant and is attached to the car's utility function. The income variable's sign is positive, indicating the higher the income the greater the probability of car being chosen. The "bus experience" variable is defined as a dummy variable equal to one if the respondent travelled by bus within the last year, and zero if not. The negative coefficient of "bus experience" in the utility function of bus indicate that people with experience of bus is less likely to use bus than those without experience, which indicated general bad experiences of people using bus.

Finally, a significant percentage of respondents only chose car (13 %) for all of the 16 different situations presented. Surprisingly, some 12 % of the respondents chose bus for all of the scenarios. Models excluding and including the "non-switching" respondents were estimated. To include the effect of "inertia to change" a dummy variable was created that is equal to one if the respondent did not switch. By excluding this variable, or by excluding those who did not switch, produced a significantly worse fit. It was therefore decided to include these records and capture its effect in the dummy variable.

The respondents who chose only car or bus were asked to give up to 3 reasons about why they did not switch. The majority of reasons of those who chose only car, indicated reasons such as:

- I like my car / I am used to my car / I prefer my car
- Bus is expensive
- Bus is too slow
- Car is more convenient and flexible.

The above reasons indicated that these respondents referred to their own experience of car, and not responding to the SP choice context. This phenomenon is often found in SP surveys and as long as the proportion of those not switching is not large and a good model can be estimated, it is not a problem. Respondents also tend to defend their existing choice behaviour.

The values of time indicated in Table 7 were estimated by taking the ratio of the coefficients of the time variables to the coefficients of the cost variables. Similar to experience elsewhere, the value of in-vehicle time of car is higher than that of bus (Wardman, 1990; Van Zyl, Lombard, and Lamprecht, 2001). Walk and wait times for busses have lower values of time than that of bus in-vehicle time. According to international experience, walk and wait times often have much higher values of time than in-vehicle time because of the greater inconvenience of walking and waiting (Wardman, 990). Some South African SP studies among low-income population groups indicated the opposite trend, similar to results of this SP study (Van Zyl, Lombard, and Lamprecht, 2001). In

Durban and Cape Town value of time of in-vehicle time were found to be less than R7 per hour, while walking and waiting time were valued similarly or even less than in-vehicle time. (Hugo and van Zyl, 2002) This may be due to the general lower values of time of low-income commuters, who do not distinguish between different ways of spending time, and possibly indicating that public transport users do not mind walking and waiting within reasonable limits. The actual walking and waiting times reported by bus users and perceived by car users are quite reasonable.

SENSITIVITY AND POLICY TESTING

The model shown in Table 7 was used to conduct sensitivity tests and a few policy tests in order to give guidance to authorities to formulate policies that would promote bus over car for middle income groups traveling over relative short distances (5 to 20 km).

The purpose of the policy tests was to determine the rank order and sensitivity of each variable in increasing the market share of bus. The logit model was first scaled to fit the observed modal shares in the Johannesburg central city. The Household Survey for Johannesburg and for the Gauteng Transport Study (2001/2002) indicated that the bus versus car split was 14 versus 86 % in Central Johannesburg (Gauteng Department of Roads and Public Works, 2004). The bus constant was therefore adjusted to show this split.

The model was subsequently applied to the observed trip data by improving each variable level with 10 per cent in turn, as an indication of the relative elasticity of bus demand relative to changes in the independent variables. Elasticity is defined as the change in demand indicated by a 1 per cent change in a factor impacting on demand (Ortuzar and Willumsen, 2006). Instead of a 1 per cent change, a 10 per cent change was tested to obtain higher demand changes in the context of a policy test. The bus costs and times were reduced, while those of car were increased, in order to obtain an increase in the bus demand. The results are shown in Table 8.

Table 8: Sensitivity test results – improve each variable level with 10 % in favour of bus

MODE	VARIABLE	% BUS SHARE	EXISTING SHARE	% INCREASE IN BUS SHARE	RANK ORDER OF VARIABLE
Car	In vehicle time	15.4	14.1	9.5	3
Car	Park cost	14.2	14.1	0.8	9
Car	Fuel cost	14.7	14.1	4.8	4
Car	Personal income	14.3	14.1	1.4	7
Bus	Wait time home end	14.3	14.1	1.9	6
Bus	Walk time home end	14.4	14.1	2.5	5
Bus	In vehicle time	15.7	14.1	11.6	1
Bus	Fare	15.4	14.1	9.7	2
Bus	Experience	14.2	14.1	1.0	8

The bus in-vehicle travel time, car travel time and bus fares indicate the highest sensitivity of around 10 % increase in bus share. Car fuel cost and bus walking time have the next highest sensitivity between 3 and 4 %, while the other variables have little impact, between 1 and 2 %. The low values of time of bus walking and waiting times coupled with the fact that these times are low and within reasonable limits, explain the low sensitivity of walk and wait times. Policies impacting on bus in-vehicle travel time, car travel time and bus fares therefore would have the most success, followed by car fuel cost and bus walking time.

The policy testing involved the estimation of the impact when variable levels are changed in combination and within practical limits. Results are indicated in Table 9. For the first two tests, all variable levels were improved with 10 % in favour of bus, and secondly, improving only the levels of the three most sensitive variables.

The bus share increased from 14 to 21 % by improving all levels with 10 %, and from 14 to 19 % by improving only the three most sensitive variables. The impact of improving only the top three variables has almost the same impact than improving all levels. The bus market shares for these tests increased by 35 and 49 % respectively.

The more realistic policy that was tested involved the following:

- Increasing bus route coverage and frequencies implying a reduction in the average walk and wait times of bus to 5 minutes;
- Implementing bus lanes and priority signaling implying an increase in current bus speed from an average speed of 24 km per hour to the average car speed of 35 km per hour;
- Take car lanes away from car for bus lanes implying a decrease in car speed from an average speed of 35 km per hour to the current average bus speed of 24 km per hour;
- Increase the fuel price with 10 cents per litre and parking cost by 10 cents per day.
- Increase subsidies in order to reduce bus fares by 10 %.

The impact of the above policy is an increase in bus share from 14 to 36 %, a percentage increase of some 150 %. The results show that a significant increase in bus shares can be obtained by following a comprehensive approach and not only improving bus, but by also restraining car. This again illustrates the success of car restraining policies internationally, such as that of London, Singapore and Hong Kong (TRB Conference Proceedings, 2005).

A final test was done by removing the negative impact of the "bus experience" variable. This shows that if all users with some experience of bus, have a positive experience of bus, the bus share increases with 11 %.

Table 9: Results of policy testing

TEST	% BUS SHARE	% INCREASE IN BUS SHARE
1. 10% Improvement for all variables combined	21	49
2. As for Test No 2, but only for in-vehicle time & cost for bus and car	19	35
3. All variable levels improve within practical limits as per described scenario	36	155
4. Removal of Bus Experience variable	15.5	11

CONCLUSIONS

In view of the increased priority locally on sustainable transport, a case study in Johannesburg undertaken to estimate mode choice factors of bus and private transport users in the inner-city areas, is reviewed to assist government on the most significant policy measures they can take to move private transport users to public transport. The study took the form of a stated preference discrete choice study conducted as part of the development of the GTS2000 transport model for Gauteng by the Gauteng Department of Transport, Roads and Public Works. SP mode choice models, simulating commuters' choice between car and bus, were successfully calibrated on the data.

The SP models provided insight into the significant factors affecting commuters' choice between car and bus in the target market segment. The significant variables in the SP model included the various travel time components, travel cost, and income. Commuters also displayed a significant inertia to change from their preferred mode of travel to another mode. An interesting finding was that commuters, who had some experience of using bus before, were reluctant to choose bus. This indicates that commuters perceived their previous usage of bus in a poor light.

The SP model confirmed the attitudes expressed by respondents in the market survey indicating that most factors affecting their choices between car and bus relate to travel time, travel cost and affordability factors, reported in terms of “cost effective”, “cheap” or “expensive”.

However, commuters’ inertia to change and apparent negative past experience of bus imply that major improvements maintained over long periods would be necessary to persuade commuters to leave their cars for bus, and also that this will be a slow process.

The bus in-vehicle travel time, car travel time and bus fares indicated the highest sensitivity of around 10 % increase in bus share in view of a 10 % improvement in these variable levels. Policies impacting on car fuel cost, bus fares and bus travel times therefore would have the most success. These would include bus lanes, BRT, increased bus subsidies, limiting road capacity for car, and some from of congestion pricing or increased petrol taxes.

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